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APOLLO 6 (A-2 OR AS-502/020) SPACECRAFT OPERATIONAL ALTERNATE MISSION PLAN

By Lunar Analysis Section
TRW Systems Group

MSC Task Monitor
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MANNED SPACECRAFT CENTER
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JEB

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By
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1. INTRODUCTION AND SUMMARY

1.1 PURPOSE

This document presents the following information concerning the AS-502 mission:

a) A summary of alternate mission capabilities and the associated mission profiles

b) Alternate mission procedures, sequence of events, and the related trajectory data

1.2 SCOPE

The Spacecraft Operational Alternate Mission Plan for Apollo Mission AS-502 defined in this document presents the alternate mission cases based upon contingencies during both the first and second S-IVB burns and during the first through the third earth parking orbit revolutions. Pertinent trajectory data for the above cases are presented in both tabular and graphical form as a function of contingency time.

The alternate mission analysis is heavily dependent upon the nominal launch vehicle and spacecraft trajectories. The initial vehicle trajectory states used in this plan were obtained from the Launch Vehicle Operational Flight Trajectory (Reference 1), and the spacecraft targeting parameters were obtained from the Spacecraft Operational Trajectory (Reference 2).

1.3 ALTERNATE MISSION DEFINITION

By definition, the alternate mission is a non-nominal mission which may be used to accomplish part of the mission objectives in the event that an inflight contingency prevents the execution of the nominal mission. The alternate mission may be distinguished from the aborted mission by the difference in objectives. The alternate mission attempts to achieve some part of the mission objectives along with an acceptable command module (CM) recovery. The aborted mission, as a result of peculiar contingency situations, is primarily concerned with an acceptable CM recovery. All acceptable alternate missions initiated during the first S-IVB burn land in the Pacific; whereas, all acceptable aborts from the first S-IVB burn

(except Mode IV aborts which are essentially alternate mission cases) land in the Atlantic.

1.4 ALTERNATE MISSION PROFILE SUMMARY

For Mission AS-502, the alternate mission plan uses the preset nominal target of the first service propulsion system (SPS) burn. When the contingency conditions permit a second SPS burn, the preset target for that nominal burn is used. The entry profile flown from an alternate mission guides the spacecraft toward the nominal preset landing target in the Pacific.

The first SPS burn, which is nominally a retrograde burn, is used to reduce the orbital energy and transfer the spacecraft from a typical lunar transfer trajectory into an earth capture ellipse with an apogee altitude of approximately 12,000 nautical miles and a perigee altitude of approximately 16 nautical miles. In the event that a contingency situation occurs during either of the S-IVB powered flight phases or during the earth parking orbit, the nominal mission sequence may be initiated by commanding separation of the S-IVB and the spacecraft command and service module (CSM). Once separation is commanded, the alternate mission begins, if no abort signal has been issued.

The alternate mission sequence of events for orientation and separation maneuvers is identical with that of the nominal mission profile (Reference 2). At 98.3 seconds after CSM/S-IVB separation, SPS ignition occurs in an attempt to achieve the nominal elliptical orbit which has an eccentricity of 0.63429326 and a semilatus rectum of 34,340,227 feet (Reference 2). The targeting criteria for SPS burns are the same for both alternate and nominal missions. The above criteria, together with other mission characteristics applicable to both nominal and alternate missions, are summarized in Table 1.

1.4.1 First S-IVB Burn

No alternate mission capability exists if the contingency situation occurs during the first 75 percent of the nominal first S-IVB burn. If the contingency occurs before 36 percent of the first S-IVB burn has been completed, any attempted SPS burn will be interrupted by the time of free fall (TFF) to entry logic of the spacecraft guidance and navigation (G&N)

system. For contingencies occurring in the next 39 percent of the first S-IVB burn, the SPS would burn in a posigrade attitude to fuel depletion without achieving the nominal target ellipse; in addition, the resulting splash points would be unacceptable. For these cases abort action would be initiated rather than an alternate mission.

If the contingency situation occurs after the first 75 percent of the nominal first S-IVB burn, the posigrade SPS burn will result in an acceptable Pacific splash point. However, the nominal first SPS ellipse will be achieved only if the contingency occurs during the last 14 percent of the nominal first S-IVB burn. Once this ellipse is achieved, the remaining SPS propellant may be used to accelerate the spacecraft prior to entry. This acceleration is an attempt to achieve the nominal second SPS burn conic which is defined by an eccentricity of 1.0164386 and a semilatus rectum of 42,418,422 feet (Reference 2). This conic is designed to produce heating conditions during entry which exceed those produced during the AS-501 mission. The second SPS conic can never be achieved for alternate missions from contingencies during the first S-IVB burn because of insufficient SPS propellant.

1.4.2 Earth Parking Orbit

The alternate mission capability during earth parking orbit is similar to the capability during the last 14 percent of the nominal first S-IVB burn. The nominal first SPS burn ellipse is achieved, and the remaining SPS propellant may be used to accelerate the spacecraft prior to entry without achieving the nominal second SPS burn conic. However, the resulting splash points limit the number of command stations that may initiate the alternate mission.

1.4.3 Second S-IVB Burn

For a contingency situation which occurs during the first 78 percent of the second S-IVB burn, the SPS will burn in a posigrade attitude to achieve the nominal first SPS burn ellipse. If the contingency situation occurs during the remaining time of the second S-IVB burn, the SPS burns in a retrograde attitude to achieve the nominal first SPS burn ellipse. Once this ellipse is achieved, the remaining SPS propellant may be used in an attempt to achieve the nominal second SPS conic. If the contingency

situation occurs during the last 51 percent of the second S-IVB burn, the second SPS burn conic can be achieved with a second SPS burn.

A flow chart for selecting either abort or alternate mission profiles for contingencies occurring during any phase of the mission is depicted in Figure 1.

2. ALTERNATE MISSION CAPABILITY

2.1 ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES DURING THE FIRST S-IVB BURN

The first contingency situation which can be considered for possible initiation of an alternate mission is the case of the S-IVB incurring a premature cutoff or a serious malfunction during its first burn while approaching parking orbit insertion. The nominal ignition time of the first S-IVB burn is at 8 minutes 43.1 seconds from lift-off, and the nominal cutoff is at 10 minutes 52.1 seconds, which represents a total burn time of 129.0 seconds (Reference 1).

For contingencies during the first S-IVB burn, if an alternate mission is desirable, the resulting sequence of events would be identical with the nominal CSM/S-IVB separation sequence listed in Table 1. SPS ignition would occur 98.3 seconds after CSM/S-IVB separation, and the SPS would burn in a posigrade attitude in an attempt to achieve the nominal first SPS burn ellipse. Once the ellipse is achieved, the remaining SPS propellant may be used to accelerate the spacecraft prior to entry. The nominal second SPS burn conic cannot be achieved because insufficient propellant remains.

A primary constraint influencing alternate mission initiation for contingency situations during the first S-IVB burn is the time of free fall (TFF) to entry interface interrupt logic. This interrupt logic, which is initiated by the guidance and navigation (G&N) system, prevents SPS ignition from occurring when the TFF to entry is equal to, or less than, 200 seconds. The logic is used to initiate CSM orientation for CM/SM separation prior to entry. This sequence applies to the nominal mission (Reference 3) as well as to the alternate mission. If the S-IVB contingency occurs before 9 minutes 30.0 seconds from lift-off, 46.9 seconds after nominal first S-IVB ignition, the TFF interrupt will occur, and no alternate mission will be possible.

The analyses presented in this report indicate that the first desirable alternate mission from contingencies during the first S-IVB burn may be initiated at 10 minutes 20.0 seconds from lift-off, 96.9 seconds into

the first S-IVB burn. This alternate mission results in an acceptable Pacific CM splash point but does not achieve the nominal first SPS burn ellipse. The nominal first SPS burn ellipse can be attained only for alternate missions initiated during the last 18 seconds of the nominal first S-IVB burn; the nominal second SPS burn conic can never be achieved. Pertinent alternate mission characteristics for contingencies during the first S-IVB burn are listed in Tables 2 and 3. Figure 2 illustrates the SPS burn time for contingencies during the first S-IVB burn. The apogee and perigee altitude and the inertial velocity and flight-path angle at entry resulting from alternate missions initiated during the first S-IVB burn are illustrated in Figures 3 and 4, respectively. The CM splash points from alternate missions during the first S-IVB burn are mapped in Figure 5. Figure 6 depicts a summary of alternate mission and abort opportunities for contingencies during the first S-IVB burn.

2.1.1 First Point to Achieve an Acceptable Pacific Landing

As shown in Figure 5, the first alternate mission that achieves an acceptable Pacific landing can be initiated at 10 minutes 20 seconds from lift-off, 96.9 seconds after nominal first S-IVB ignition. This splash point is approximately 650 nautical miles west of the North American mainland which is believed to be sufficient range to allow for reasonable dispersions.

An alternate mission initiated at this time will not achieve the nominal first SPS burn ellipse. The SPS will burn to fuel depletion, attaining an ellipse with a 10,859-nautical mile apogee altitude and a 22-nautical mile perigee altitude. This ellipse will result in an inertial velocity at entry of 32,568 feet per second and an inertial flight-path angle at entry of 5.05 degrees below the local horizontal. Applicable alternate mission characteristics for this case are given in Table 4. Figure 7 illustrates the tracking and communications coverage available during the SPS burn. It should be noted that there is a region during the middle of the burn for which no coverage exists (approximately 3 minutes).

2.1.2 First Point to Achieve the Nominal First SPS Burn Ellipse

A unique alternate mission exists which has the capability to achieve the nominal first SPS burn ellipse from contingencies during the first S-IVB burn. The case is unique in that it is the first contingency situation

for which an SPS guidance cutoff occurs. As shown in Figure 2, the first alternate mission from contingencies during the nominal first S-IVB burn that achieves the nominal first SPS burn ellipse occurs at 10 minutes 34 seconds from lift-off, 110.9 seconds into the nominal first S-IVB burn. Table 5 provides a synopsis of the applicable alternate mission characteristics and indicates that an inertial velocity of 32,806 feet per second and an inertial flight-path angle of 5.952 degrees below the local horizontal are achieved at entry for the above alternate mission. These values are identical to those obtained from the nominal first SPS burn. The tracking and communications coverage available during the SPS burn phase is presented in Figure 8. It should be noted that there is a region during the middle of the burn for which no coverage exists (approximately 2.5 minutes).

2.2 ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES DURING THE FIRST THROUGH THE THIRD EARTH PARKING ORBIT REVOLUTIONS

The nominal first S-IVB burn places the spacecraft, which is still attached to the S-IVB stage, in a near earth circular parking orbit of approximately 100 nautical miles altitude. At the end of two revolutions in earth parking orbit, the nominal mission calls for second S-IVB ignition to occur at a longitude position near the launch site. Contingency situations may occur during these parking orbit revolutions which would require sending the CSM/S-IVB separation signal. A similar situation would exist if the second S-IVB ignition does not occur. For this case, it is assumed that the spacecraft will have approximately one more revolution in parking orbit to achieve S-IVB ignition before the S-IVB critical systems lifetime has expired. Alternate missions have thus been considered from the first through the third earth parking orbit revolutions.

For contingencies during the first through the third earth parking orbit revolutions, if an alternate mission is desirable, the resulting sequence of events would be identical with the nominal CSM/S-IVB separation sequence. SPS ignition would occur 98.3 seconds after CSM/S-IVB separation in an attempt to achieve the nominal first SPS burn ellipse. The SPS would burn to guidance cutoff in a posigrade attitude to achieve the nominal first SPS burn ellipse. A small amount of SPS propellant

remains (equivalent to 17.00 seconds of SPS burn time) and may be used to accelerate the spacecraft prior to entry, but the nominal second SPS conic cannot be achieved.

Figure 9 presents the tracking and communications coverage available during the three revolutions in earth parking orbit. It is assumed that the CSM/S-IVB separation signal can be sent only by command tracking stations which have ultra-high frequency (UHF) or unified S-band (USB) capability. However, acceptable CM splash points limit the number of command tracking stations that can be considered for alternate mission initiation. If the alternate mission is initiated by Guaymas, White Sands, Texas, Cape Kennedy, Patrick Air Force Base, Grand Bahama, Bermuda, or the Insertion Ship, an acceptable CM splash point will be reached. Tables 6 and 7 present the characteristics for alternate missions initiated by three of the considered command stations (Guaymas, Texas, and Insertion Ship).

2.3 ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES DURING THE SECOND S-IVB BURN

The third contingency situation to be investigated for the AS-502 mission is the case in which the S-IVB experiences a serious malfunction during the second burn while leaving earth parking orbit. The ignition time of the second S-IVB burn is 3 hours 10 minutes 9.4 seconds from lift-off, and the cutoff is at 3 hours 15 minutes 36.7 seconds, which represents a total burn time of 327.3 seconds.

As in the case of the previously discussed contingencies for alternate missions, the SPS is ignited 98.3 seconds after CSM/S-IVB separation. The SPS experiences a guidance cutoff achieving the nominal first SPS burn ellipse. After attaining the target ellipse, some SPS propellant remains for all cases. A second SPS burn may be desirable in an attempt to achieve the nominal inertial velocity and flight-path angle at entry. The second SPS burn is a scheduled guidance event which is identical to that of the nominal mission (Table 1). The second SPS ignition occurs near the end of the flight when TFF to entry interface is 509.089 seconds. The nominal entry conditions, which depend on achieving the second SPS conic,

can be achieved by a second SPS burn for contingencies occurring after 3 hours 12 minutes 48 seconds from lift-off, 158.6 seconds after the nominal second S-IVB ignition. The first SPS burn will occur in a retrograde attitude for alternate missions from contingencies after 3 hours 14 minutes 24 seconds from lift-off, 254.6 seconds after the nominal second S-IVB ignition. A contingency occuring at 3 hours 14 minutes 32 seconds from lift-off, 262.6 seconds after the nominal second S-IVB ignition, will experience the minimum first SPS burn time of 125.63 seconds to achieve the nominal first SPS burn ellipse and the maximum second SPS burn time of 232.22 seconds to achieve the nominal second SPS burn conic.

Significant alternate mission characteristics, including heating characteristics during entry, are illustrated in Tables 8 and 9 for contingencies during the second S-IVB burn, with or without a second SPS burn. Figures 11 and 12 depict the entry conditions resulting from alternate missions during the second S-IVB burn, with or without a second SPS burn. The CM splash points for these cases are mapped in Figure 13. As may be noted in Figure 13, all alternate missions with a second SPS burn capability land in the target area.

2.3.1 No Second S-IVB Burn

The case of no second S-IVB burn was investigated to determine the alternate mission capability from a contingency at nominal second S-IVB ignition (3 hours 10 minutes 9.4 seconds from lift-off). The pertinent trajectory characteristics for this case are listed in Tables 10 and 11 with or without a second SPS burn.

Since this case does not benefit from the ΔV of the second S-IVB burn, it is similar to the alternate mission cases from earth parking orbit. The nominal first SPS burn ellipse is achieved, but insufficient SPS propellant remains to achieve the nominal second SPS burn conic. The CM splash point for this case is included with the other splash points for alternate missions during the second S-IVB burn in Figure 13. Tracking and communications coverage during the SPS burns for the case of no second S-IVB burn is shown in Figure 14. The figure indicates that the SPS burns are adequately covered.

2. 3. 2 First Point to Achieve the Nominal Second SPS Burn Conic

Another unique case for alternate missions originating during the second S-IVB burn is the first contingency situation which will permit the second SPS burn guidance cutoff and thus achieve the nominal second SPS target conic. This conic is designed to produce the nominal entry conditions (inertial velocity equals 36, 500 feet per second, flight-path angle equals 6. 495 degrees below the local horizontal) which, in turn, produce the desired heating objectives described in Reference 2.

Figure 10 illustrates that a contingency time of 3 hours 12 minutes 48 seconds from lift-off, 158. 6 seconds into the second S-IVB burn, is the earliest point when an alternate mission may be initiated that can accomplish both the nominal first SPS burn ellipse and the nominal second SPS burn conic. This corresponds to a time approximately 49 percent through the second S-IVB burn. The significant trajectory parameters of this case are presented in Table 12.

Tracking and communication coverage during both of these SPS burns is shown in Figure 15 and appears satisfactory.

Table 1. Characteristics Common to Nominal and Alternate Missions[1]

- Launch at 1300 hours (GMT),[2] 20 March 1968
- CSM/S-IVB trajectory (Reference 1)
- CSM/S-IVB separation sequence (Reference 2)
  1) 1.7-second ullage prior to physical separation
  2) CSM/S-IVB separation
  3) 8.3 seconds of spacecraft plus X-axis translation
  4) 90 seconds of spacecraft reorientation and attitude hold
- First SPS burn ellipse

  Semilatus rectum = 34, 340, 227 feet

  Eccentricity = 0.63429326
- Second SPS ignition signal

  Time of free fall (TFF) to entry = 509.089 seconds
- Second SPS burn conic

  Semilatus rectum = 42, 418, 422 feet

  Eccentricity = 1.0164386
- SPS usable propellant for alternate missions (Reference 4)

  31, 632 pounds (equivalent to 460.1 seconds of total burn time)
- CM/SM separation sequence (Reference 2)
  1) CM/SM orientation prior to separation when TFF = 200 seconds
  2) CM/SM separation when TFF = 85 seconds
  3) CM/SM orientation for entry when TFF = 80 seconds
- Drogue chute deployment

  Altitude = 23, 500 feet
- Main chute deployment

  Altitude = 10, 200 feet
- CM splash target

  Geodetic latitude = 27.323° North

  Longitude = 157.179° West

[1] The constants contained in this report are appliable only to the data contained in this report. The latest data specification will be used as the official source to revise data when necessary.

[2] 0800 hours, EST

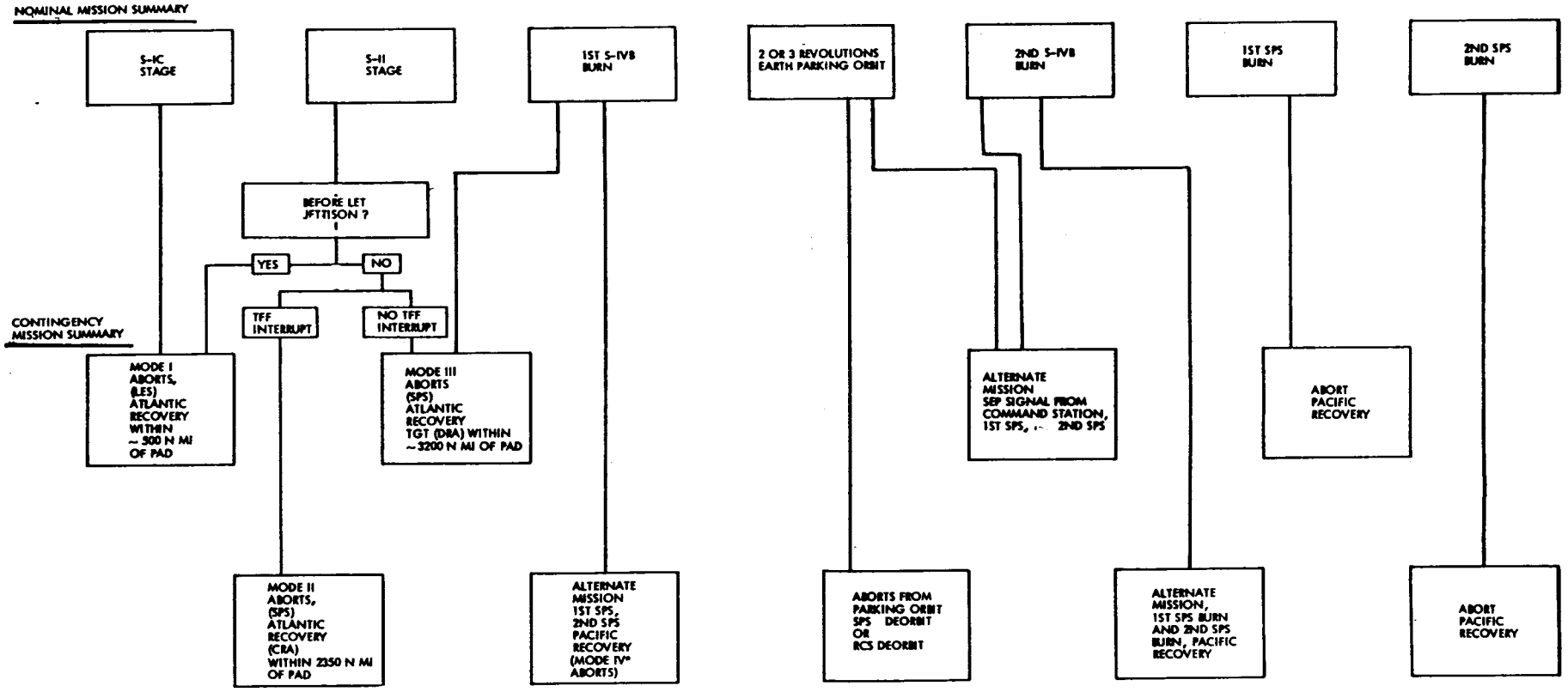


Figure 1. Summary of Alternate Mission and Abort Contingency Situations

Table 2. Alternate Mission Characteristics from Contingencies During the First S-IVB Burn Without Second SPS Burn

Time of Contingency from Lift-off (hr:min:sec)	Time from Nominal First S-IVB Ignition (sec)	SPS Burn Duration (sec)	Apogee[2] Altitude (n mi)	Perigee[2] Altitude (n mi)	Entry Conditions				CM Splash Conditions[1]			
					Geodetic Latitude[3] (deg)	Longitude[3] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[3] (deg)	Geodetic Latitude[3] (deg)	Longitude[3] (deg)	Total Miss (n mi)	Time from Lift-off (hr:min:sec)
00:09:30.0	46.9	460.10	7,653	39	32.42	-124.35	31,681	-4.073	21.36	-62.50	5,073	04:52:46[4][5]
00:09:40.0	56.9	460.10	8,169	36	32.34	-129.09	31,851	-4.314	24.37	-82.23	4,000	05:03:20[5]
00:10:00.0	76.9	460.10	9,382	29	32.17	-139.94	32,206	-4.873	29.58	-109.06	2,532	05:33:05[5]
00:10:20.0	96.9	460.10	10,859	22	31.82	-153.16	32,568	-5.505	30.68	-128.08	1,541	06:13:56[6]
00:10:34.0	110.9	460.10	11,994	16	31.54	-163.74	32,806	-5.952	32.25	-147.11	603	06:45:04[7]
00:10:40.0	116.9	454.10	11,994	16	31.54	-163.77	32,806	-5.952	32.24	-147.13	601	06:44:58
00:10:52.1	129.0	443.51	11,994	16	31.43	-164.48	32,806	-5.952	32.24	-147.87	568	06:44:52[8]
									Target 27.32	-157.18		

[1] All landings occur during daylight.

[2] Altitude is measured above the spherical reference body.

[3] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[4] First case of an uninterrupted (due to TFF logic) SPS burn; nominal first SPS ellipse not achieved

[5] Abort action taken to land in Atlantic

[6] First case of an acceptable Pacific landing, nominal first SPS ellipse not achieved

[7] Case of the first point to achieve the nominal first SPS burn ellipse

[8] Nominal first S-IVB cutoff

Table 3. Alternate Mission Characteristics from Contingencies During the First S-IVB Burn with Second SPS Burn

Apogee Altitude = 11, 994 n mi
Perigee Altitude = 16 n mi

Time of Contingency from Lift-off (hr:min:sec)	Time from Nominal First S-IVB Ignition (sec)	SPS Burn Duration[1]		Entry Conditions				CM Splash Conditions[2]			
		First Burn (sec)	Second Burn[3] (sec)	Geodetic Latitude[4] (deg)	Longitude[4] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[4] (deg)	Geodetic Latitude[4] (deg)	Longitude[4] (deg)	Total Miss Distance (n mi)	Time from Lift-off (hr:min:sec)
00:10:34.0	110.9	460.10	0.00	31.54	-163.74	32,806	-5.952	32.25	-147.11	603	06:45:04
00:10:35.0	111.9	458.14	1.96	31.56	-163.59	32,852	-5.954	32.24	-146.93	611	06:45:02
00:10:40.0	116.9	454.10	6.00	31.47	-164.13	32,945	-6.012	32.24	-147.55	582	06:44:51
00:10:45.0	121.9	449.74	11.36	31.46	-164.28	33,078	-5.849	32.13	-146.84	612	06:44:56
00:10:52.1	129.0	443.51	16.59	31.35	-165.02	33,193	-5.943	32.18	-147.86	567	06:44:45[5]
							Target	27.32	-157.18		

[1] Nominal first SPS ellipse achieved

[2] All landings occur in daylight.

[3] All second SPS burns experience fuel depletion cutoff; second SPS burn conic not achieved

[4] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[5] Nominal first S-IVB cutoff

Table 4. Alternate Mission Characteristics for the Case of the First Acceptable Pacific Landing

Event	Time From Lift-off (hr:min:sec)	Altitude[1] (ft)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Inertial Azimuth (deg)
Contingency	00:10:20.0	629,014	32.47	-58.25	24,750	-0.095	85.62
CSM/S-IVB Separation	00:10:21.7	628,950	32.48	-58.13	24,750	-0.103	85.69
SPS Ignition	00:11:60.0	614,533	32.74	-50.87	24,772	-0.588	89.82
SPS Cutoff	00:19:40.1	1,431,190	26.77	-14.15	31,615	12.068	109.49[3]
Apogee	03:08:27.8	66,001,220	-32.73	87.12	7,949	0.000	88.95
Entry Interface	06:00:45.6	400,000	31.82	-153.16	32,568	-5.505	81.95
Drogue Chute Deployment	06:08:10.0	23,500	30.68	-128.08	1,356	-18.970	90.29
Main Chute Deployment	06:08:58.0	10,200	30.68	-128.08	1,342	-9.728	90.00
CM Splash	06:13:56.0	0	30.68	-128.08	1,322	-1.200	90.00

[1] Altitude is measured above the Fischer Reference Ellipsoid.

[2] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal

[3] SPS Fuel depletion cutoff; nominal first SPS ellipse not achieved.

Table 5. Alternate Mission Characteristics for the Case of the First Point to Achieve the Nominal First SPS Burn Ellipse

Event	Time From Lift-off (hr:min:sec)	Altitude[1] (ft)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Inertial Azimuth (deg)
Contingency	00:10:34.0	628,341	32.54	-57.20	25,100	-0.078	86.20
CSM/S-IVB Separation	00:10:35.7	628,290	32.55	-57.07	25,100	-0.082	86.27
SPS Ignition	00:12:14.0	620,611	32.74	-49.70	25,099	-0.285	90.46
SPS Cutoff	00:19:53.9	1,617,068	26.40	-13.03	31,697	13.184	110.00[3]
Apogee	03:25:14.8	72,901,130	-32.74	81.68	7,412	0.000	89.64
Entry Interface	06:34:22.2	400,000	31.54	-163.74	32,806	-5.952	80.81
Drogue Chute Deployment	06:39:18.0	23,500	32.25	-147.11	1,360	-19.340	91.20
Main Chute Deployment	06:40:06.0	10,200	32.25	-147.11	1,342	-9.728	90.00
CM Splash	06:45:04.0	0	32.25	-147.11	1,322	-1.200	90.00

[1]Altitude is measured above the Fischer Reference Ellipsoid.

[2]Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[3]SPS guidance cutoff.

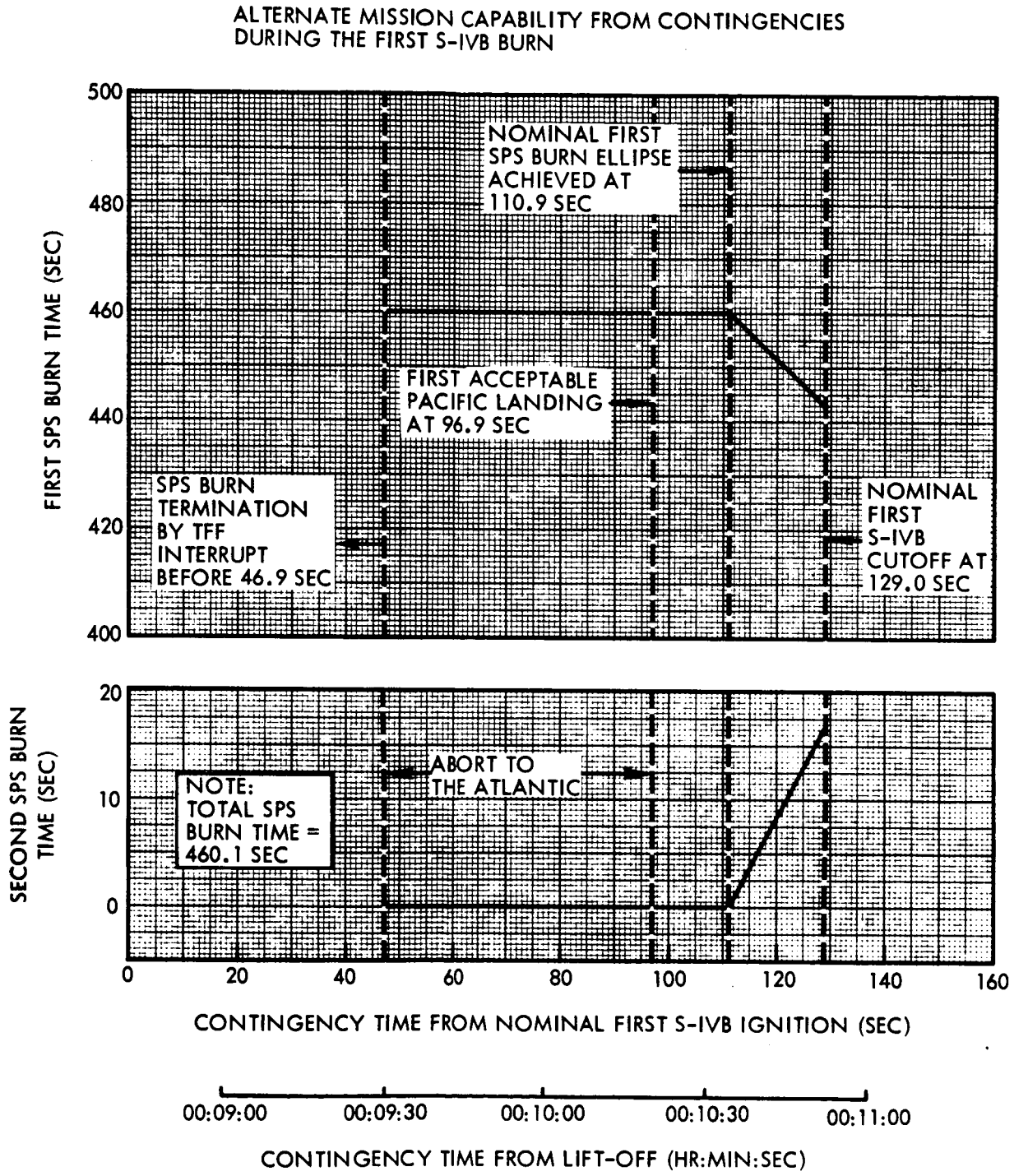


Figure 2. SPS Burn Time for Contingencies During the First S-IVB Burn

ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES
DURING THE FIRST S-IVB BURN

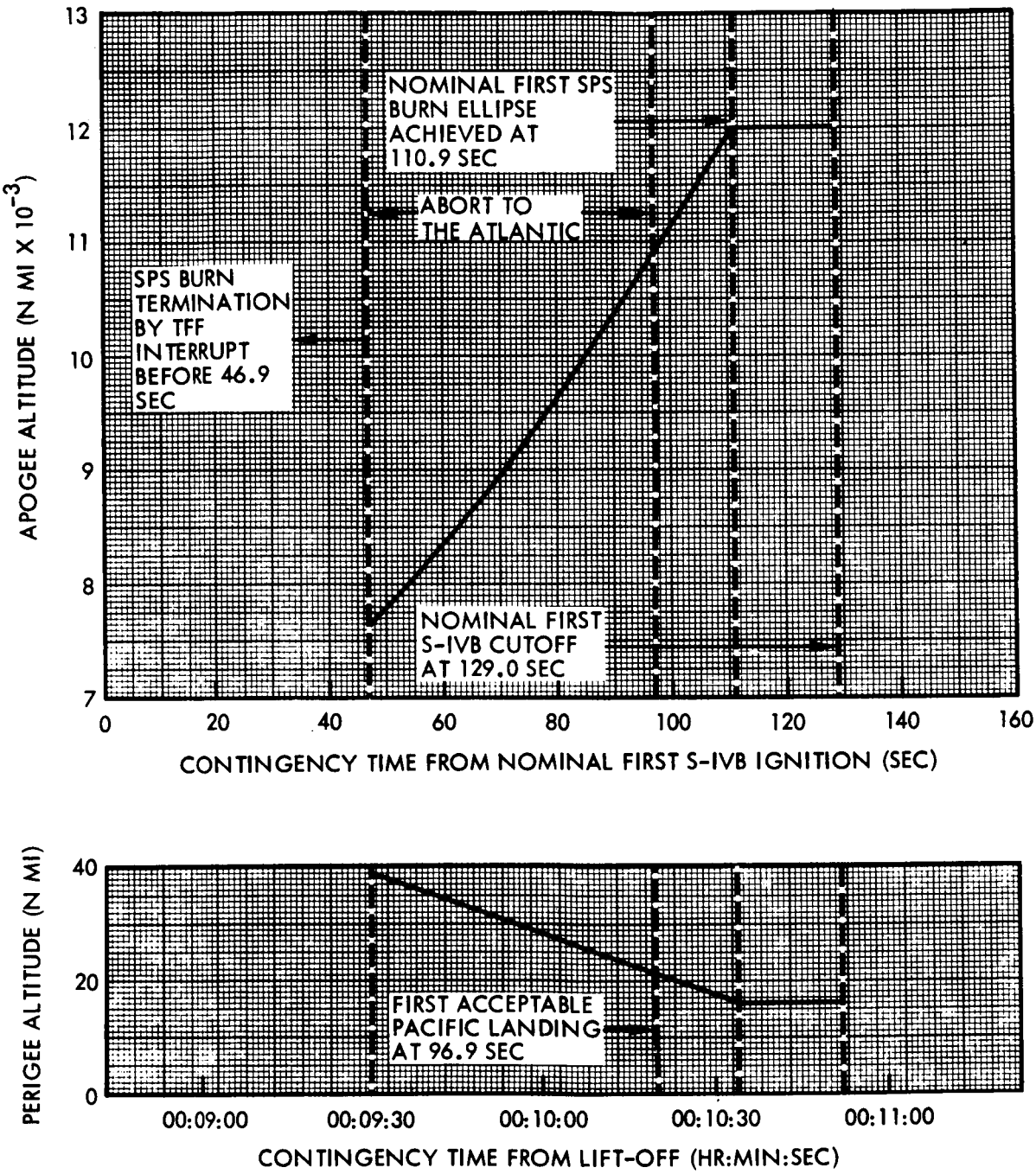


Figure 3. Apogee and Perigee Altitude for Contingencies During the First S-IVB Burn

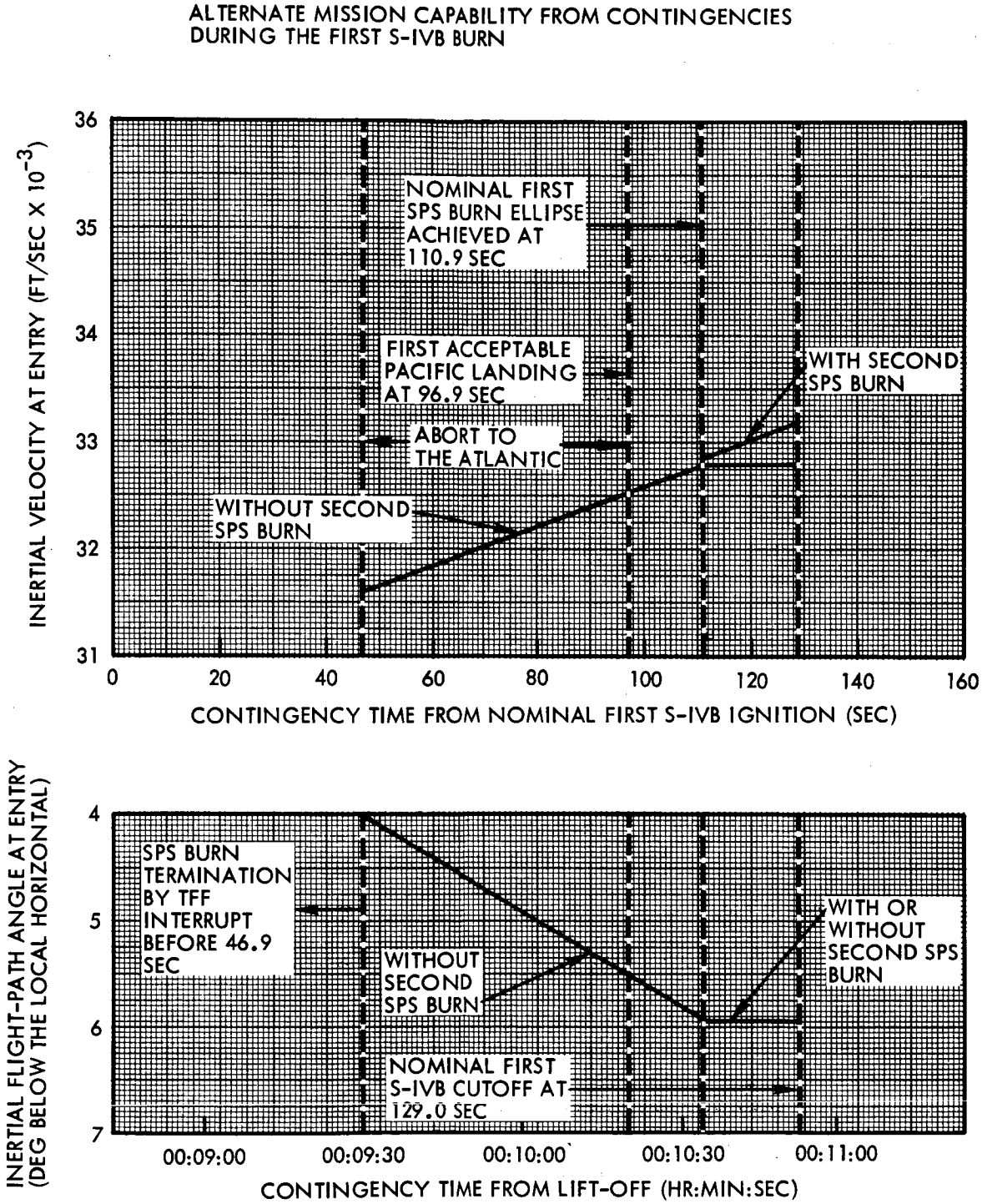


Figure 4. Inertial Velocity and Flight-path Angle at Entry for Contingencies During the First S-IVB Burn

ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES
DURING THE FIRST S-IVB BURN

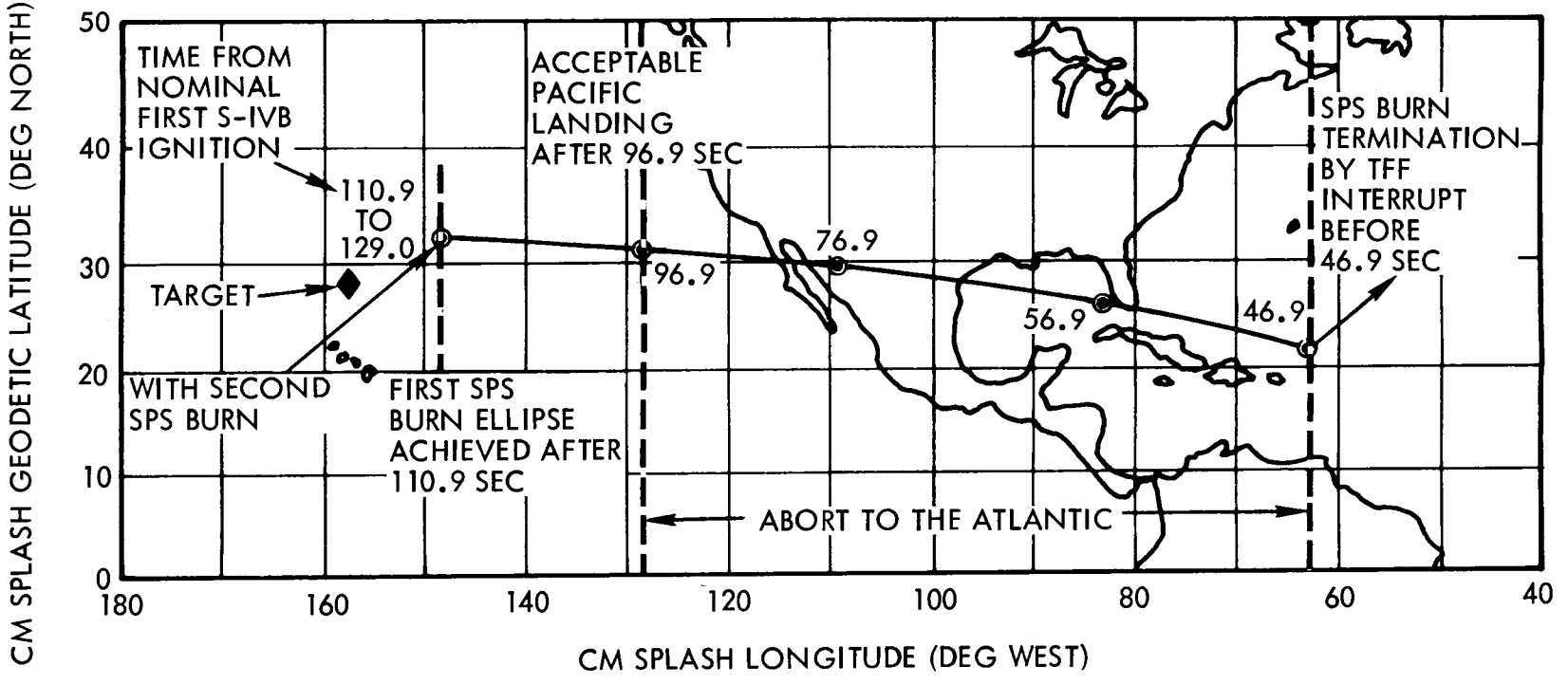
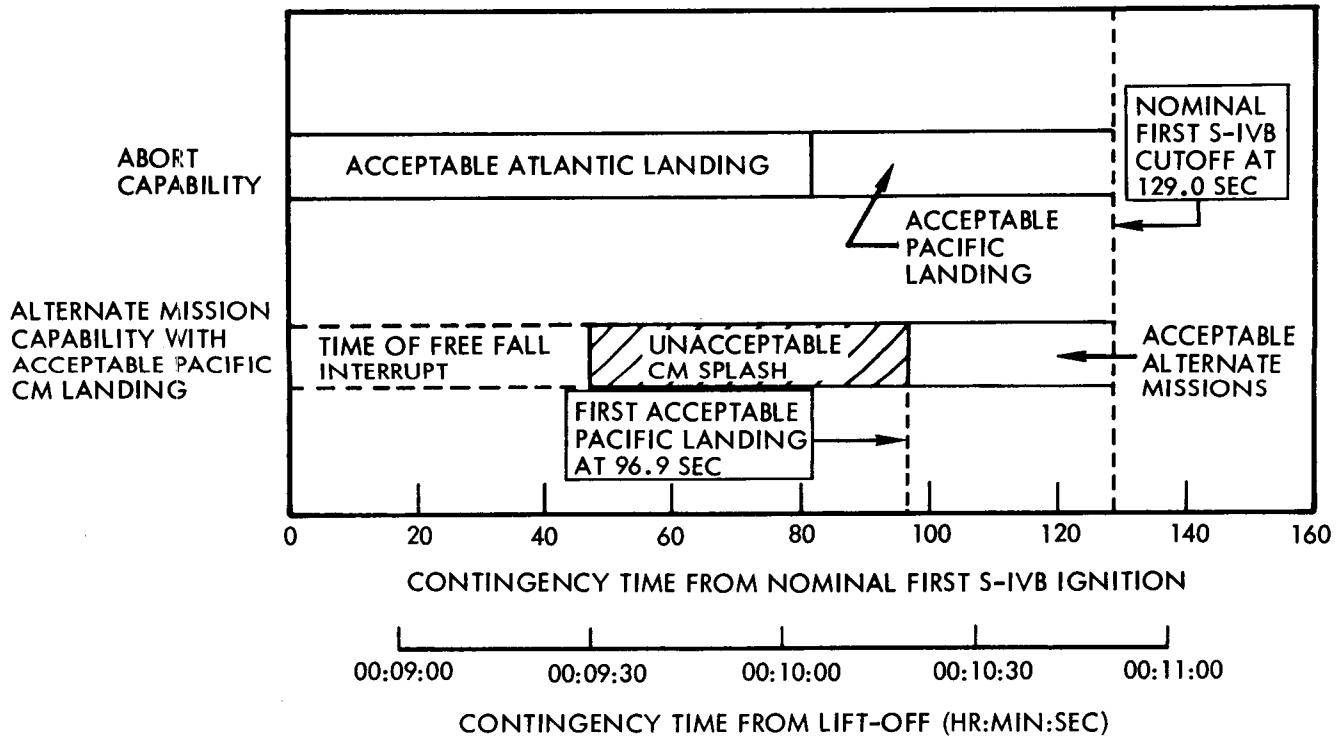


Figure 5. Map of CM Splash Points for Contingencies During the First S-IVB Burn

ALTERNATE MISSION CAPABILITY FROM CONTINGENCIES
DURING THE FIRST S-IVB BURN



NOTE: ABORT CAPABILITY BASED ON 32,611 POUNDS OF USABLE SPS PROPELLANT

Figure 6. Alternate Mission and Abort Summary for Contingencies During the First S-IVB Burn

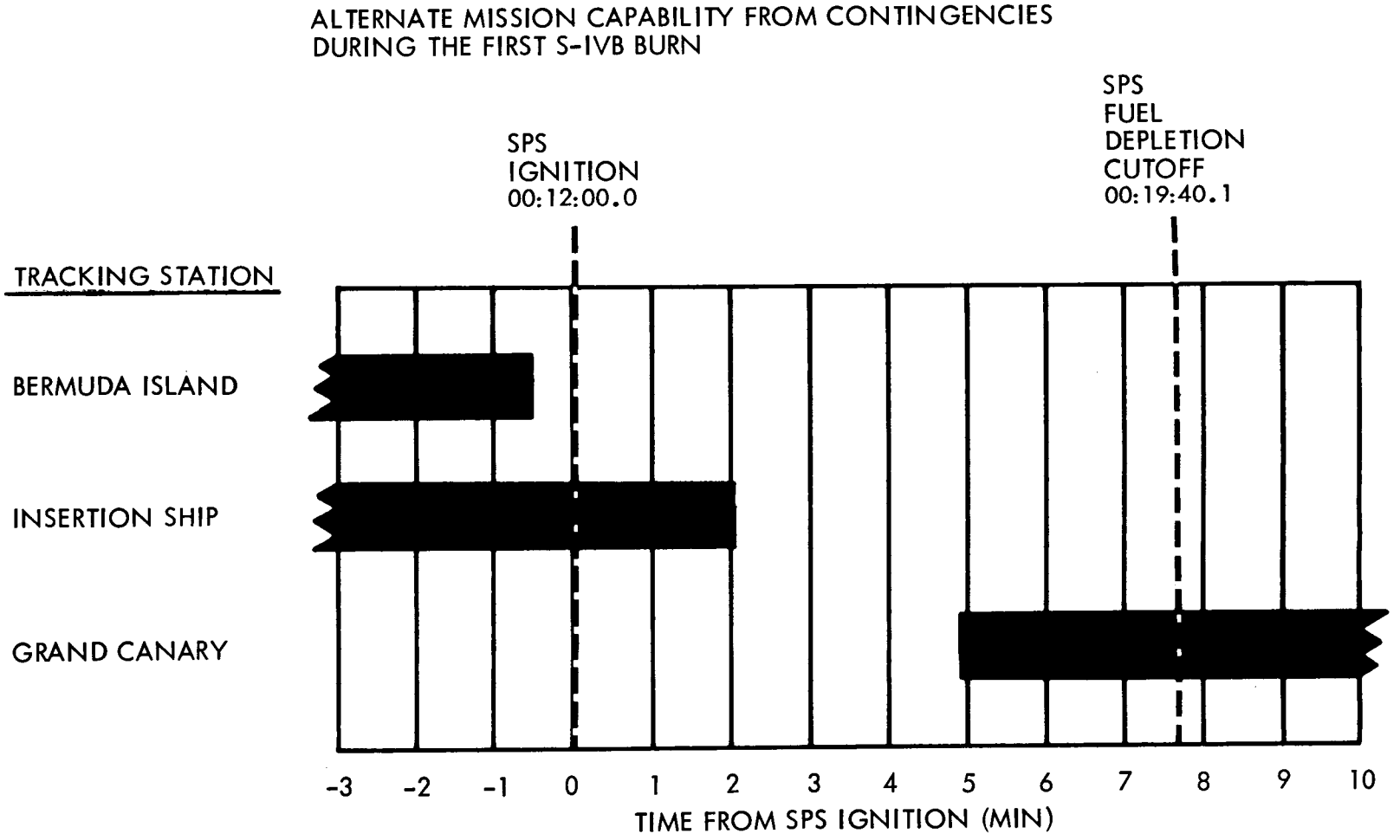


Figure 7. Tracking and Communications Coverage versus SPS Burn Time; Case of the First Point to Achieve an Acceptable Pacific Landing

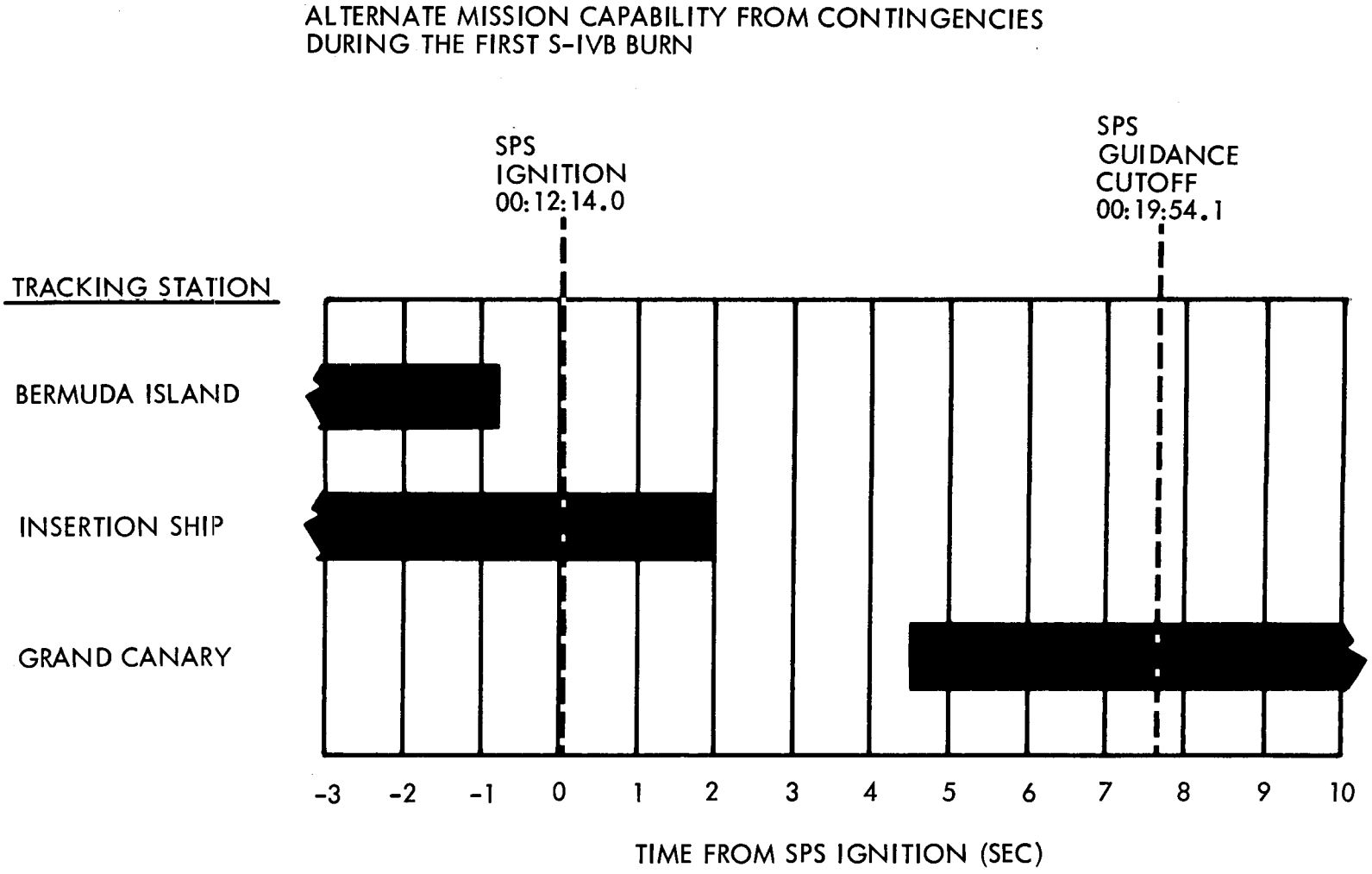


Figure 8. Tracking and Communications Coverage versus SPS Burn Time; Case of the First Point to Achieve the Nominal First SPS Burn Ellipse

Table 6. Alternate Mission Characteristics from Earth Parking Orbit Contingencies Without Second SPS Burn

Apogee Altitude = 11,994 n mi
Perigee Altitude = 16 n mi
Entry Inertial Velocity = 32,806 ft/sec
Maximum Acceleration During Entry ≈ 5 g's
Maximum Heat Rate During Entry = 196 BTU/ft^2-sec
Total Heat Load During Entry = 26,500 BTU/ft^2
Entry Inertial Flight-path Angle = 5.952 deg below the local horizontal

Case Number	Command Station	Contingency Conditions: Parking Orbit Revolution	Contingency Conditions: Time from Lift-off (hr:min:sec)	Contingency Conditions: Geodetic[2] Latitude (deg)	Contingency Conditions: Longitude[2] (deg)	Entry Conditions: Geodetic[2] Latitude (deg)	Entry Conditions: Longitude[2] (deg)	CM Splash Conditions[1]: Geodetic[2] Latitude (deg)	CM Splash Conditions[1]: Longitude[2] (deg)	CM Splash Conditions[1]: Total Miss Distance (n mi)	CM Splash Conditions[1]: Time from Lift-off (hr:min:sec)
1	Insertion Ship (LOS)[3]	1	00:14:00.0	32.37	-41.50	32.69	-150.26	29.49	-126.59	1620	06:50:00
2	Guaymas (AOS)[4]	1	01:29:15.0	22.87	-119.36	18.12	133.89	30.68	-171.41	775	08:16:43
3	Texas (AOS)	1	01:32:15.0	27.34	-107.53	23.44	145.06	29.75	-156.02	158	08:19:18
4	Insertion Ship (LOS)	2	01:47:30.0	27.82	-40.12	30.62	-148.13	22.54	-125.98	1722	08:23:20
5	Guaymas (AOS)	2	03:02:30.0	29.90	-120.74	26.81	131.34	28.65	-161.81	310	09:51:35
6	Texas (AOS)	2	03:05:45.0	32.22	-106.31	30.49	145.17	27.31	-157.18	0	09:51:13
7	Insertion Ship (LOS)	3	03:20:30.0	20.05	-43.36	24.61	-150.24	16.37	-130.10	1643	09:55:58
8	Guaymas (AOS)	3	04:35:45.0	32.72	-119.85	31.90	131.43	26.95	-171.80	783	11:22:11
9	Texas (AOS)	3	04:38:45.0	32.10	-106.13	32.72	145.12	23.05	-162.73	396	11:24:19
10	Cape Kennedy	4	04:44:41.4	26.33	-80.60	29.57	171.65	22.66	-162.61	407	11:23:35
								Target 27.32	-157.18		

(1) All landings occur in daylight.

(2) Minus sign indicates south latitude or west longitude.

(3) LOS - loss of signal

(4) AOS - acquisition of signal

Table 7. Alternate Mission Characteristics from Earth Parking Orbit Contingencies with Second SPS Burn

Apogee Altitude = 11,994 n mi
Perigee Altitude = 16 n mi
Entry Inertial Velocity = 33,205 ft/sec
Maximum Acceleration During Entry ≈ 12 g's
Maximum Heat Rate During Entry = 213 BTU/ft^2-sec
Total Heat Load During Entry = 26,886 BTU/ft^2
Entry Inertial Flight-path Angle = 5.952 deg below the local horizontal

	Contingency Conditions					Entry Conditions		CM Splash Conditions[1]			
Case Number	Command Station	Parking Orbit Revolution	Time from Lift-off (hr:min:sec)	Geodetic[2] Latitude (deg)	Longitude[2] (deg)	Geodetic[2] Latitude (deg)	Longitude[2] (deg)	Geodetic[2] Latitude (deg)	Longitude[2] (deg)	Total Miss Distance (n mi)	Time from Lift-off (hr:min:sec)
1	Insertion Ship (LOS)[3]	1	00:14:00.0	32.37	-41.50	32.67	-150.89	29.70	-127.13	1592	06:49:41
2	Guaymas (AOS)[4]	1	01:29:15.0	22.87	-119.36	17.84	133.40	29.80	-158.82	172	08:19:27
3	Texas (AOS)	1	01:32:15.0	27.34	-107.53	23.30	144.76	28.65	-150.17	381	08:18:03
4	Insertion Ship (LOS)	2	01:47:30.0	27.82	-40.12	30.74	-148.73	23.22	-127.34	1638	08:22:45
5	Guaymas (AOS)	2	03:02:30.0	29.90	-120.74	26.71	131.07	22.21	-144.38	763	09:52:34
6	Texas (AOS)	2	03:05:45.0	32.22	-106.31	30.40	144.76	26.98	-156.11	61	09:49:13
7	Insertion Ship (LOS)	3	03:20:30.0	20.05	-43.36	24.85	-150.82	16.56	-130.42	1621	09:55:46
8	Guaymas (AOS)	3	04:35:45.0	32.72	-119.85	31.82	130.80	21.34	-158.58	366	11:25:29
9	Texas (AOS)	3	04:38:45.0	32.10	-106.13	32.72	144.50	21.10	-158.58	380	11:23:16
10	Cape Kennedy	4	04:44:41.4	26.33	-80.60	29.73	171.02	22.45	-161.77	384	11:23:43
								Target 27.32	-157.18		

[1] All landings occur in daylight.

[2] Minus sign indicates south latitude or west longitude.

[3] LOS - loss of signal

[4] AOS - acquisition of signal

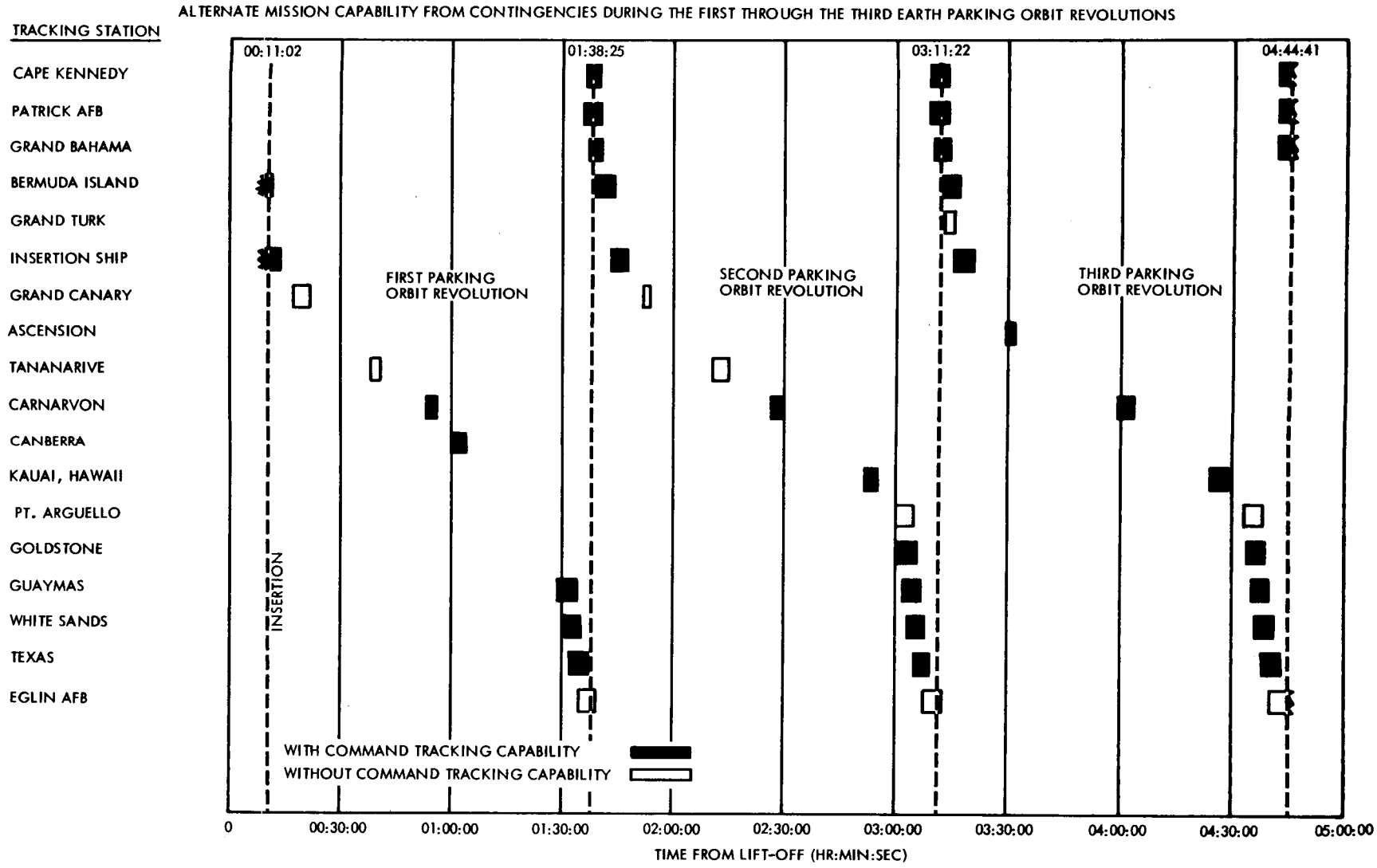


Figure 9. Tracking and Communications Coverage versus Time from Lift-off

Table 8. Alternate Mission Characteristics from Contingencies During the Second S-IVB Burn Without Second SPS Burn

Apogee Altitude = 11, 994 n mi
Perigee Altitude = 16 n mi
Entry Inertial Velocity = 32, 806 ft/sec
Maximum Acceleration During Entry = 4. 94 g's
Maximum Heat Rate During Entry = 196 BTU/ft^2-sec
Total Heat Load During Entry = 26, 500 BTU/ft
Entry Inertial Flight-path Angle = 5. 952 deg below the local horizontal

Time of Contingency from Lift-off (hr:min:sec)	Time from Nominal Second S-IVB (sec)	First SPS Burn Duration (sec)	Entry Conditions		CM Splash Conditions[1]			
			Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Total Miss Distance (n mi)	Time from Lift-off (hr:min:sec)
03:10:09. 4	0. 0	444. 95	32. 61	162. 39	28. 26	-160. 23	172	09:51:49
03:10:30. 0	20. 0	429. 49	32. 61	162. 16	28. 22	-160. 10	165	09:51:51
03:11:00. 0	50. 6	404. 18	32. 60	162. 16	28. 18	-159. 91	154	09:51:48
03:11:30. 0	80. 6	375. 81	32. 59	161. 86	28. 12	-159. 69	142	09:51:51
03:12:00. 0	110. 6	343. 32	32. 56	161. 49	27. 99	-159. 29	119	09:51:52
03:12:30. 0	140. 6	304. 43	32. 52	160. 95	27. 87	-158. 84	94	09:51:54
03:12:48. 0	158. 6	277. 87	32. 50	160. 55	27. 73	-158. 46	73	09:52:00
03:13:00. 0	170. 6	258. 69	32. 48	160. 33	27. 62	-158. 10	52	09:52:02
03:13:30. 0	200. 6	207. 56	32. 43	159. 74	27. 53	-157. 76	22	09:51:45
03:14:00. 0	230. 6	157. 40	32. 39	159. 34	27. 44	-157. 45	15	09:51:44
03:14:24. 0	254. 6	129. 60	32. 36	159. 29	27. 36	-157. 20	5	09:51:43 (3)
03:14:30. 0	260. 6	126. 08	32. 35	159. 29	27. 34	-157. 15	2	09:50:47
03:14:32. 0	262. 6	125. 63	32. 35	159. 30	27. 33	-157. 17	1	09:50:36 (4)
03:15:00. 0	290. 6	146. 91	32. 34	159. 68	27. 34	-157. 15	2	09:50:56
03:15:36. 7	327. 3	237. 91	32. 34	159. 87	27. 30	-157. 13	3	09:50:37 (5)
					Target 27. 32	-157. 18		

[1] All landings occur during daylight.

[2] Minus sign indicates south latitude or west longitude.

[3] Case of the first retrograde first SPS burn

[4] Case of the minimum first SPS burn duration

[5] Nominal second S-IVB cutoff

Table 9. Alternate Mission Characteristics from Contingencies During the Second S-IVB Burn with Second SPS Burn

Apogee Altitude = 11, 994 n mi
Perigee Altitude = 16 n mi

Time of Contingency from Lift-off (hr:min:sec)	Time from Nominal Second S-IVB Ignition (sec)	SPS Burn Duration		Entry Conditions							CM Splash Conditions[1]			
		First Burn (sec)	Second Burn (sec)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Maximum Acceleration (g)	Maximum Heat Load (BTU/ft²-sec)	Total Heat Load (BTU/ft²)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Total Miss Distance (n mi)	Time from Lift-off (hr:min:sec)
03:10:09.4	0.0	444.95	15.15	32.59	161.87	33,161	-5.920	4.94	196	27,627	27.35	-157.24	3	09:51:33
03:10:30.0	20.6	429.49	30.61	32.56	161.63	33,515	-5.790	4.98	210	28,520	27.35	-157.15	2	09:51:16
03:11:00.0	50.6	404.18	55.92	32.48	160.14	34,062	-6.088	5.05	222	30,564	27.35	-157.16	2	09:51:53
03:11:30.0	80.6	375.81	84.29	32.42	159.19	34,655	-6.151	5.15	240	31,877	27.34	-157.16	2	09:51:13
03:12:00.0	110.6	343.32	116.78	32.33	158.11	35,304	-6.266	5.30	270	34,205	27.34	-157.24	3	09:51:54
03:12:30.0	140.6	304.43	155.67	32.21	156.94	36,042	-6.410	5.55	320	36,746	27.32	-157.17	3	09:51:33
03:12:48.0	158.6	277.87	181.38	32.16	156.27	36,500	-6.496	5.73	370	38,800	27.30	-157.16	2	09:50:33[3]
03:13:00.0	170.6	258.69	187.81	32.12	156.06	36,500	-6.496	5.73	370	38,800	27.30	-157.16	2	09:50:29
03:13:30.0	200.6	207.56	204.96	32.06	155.60	36,500	-6.495	5.73	370	38,800	27.30	-157.16	2	09:50:29
03:14:00.0	230.6	157.40	221.67	32.00	155.30	36,500	-6.495	5.73	370	38,800	27.31	-157.16	1	09:50:29
03:14:24.0	254.6	129.60	230.91	31.99	155.28	36,500	-6.495	5.73	370	38,800	27.30	-157.16	1	09:50:16
03:14:30.0	260.6	126.08	232.02	31.99	155.27	36,500	-6.495	5.73	370	38,800	27.30	-157.17	1	09:50:18
03:14:32.0	262.6	125.63	232.22	31.98	155.34	36,500	-6.494	5.73	370	38,800	27.30	-157.17	1	09:50:17[4]
03:15:00.0	290.6	146.91	225.13	31.97	155.63	36,500	-6.495	5.73	370	38,800	27.30	-157.16	2	09:50:02
03:15:36.7	327.3	237.91	194.79	31.96	155.70	36,500	-6.498	5.73	370	38,800	27.30	-157.17	1	09:49:39[5]
											Target 27.32	-157.18		

[1] All landings occur during daylight.

[2] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[3] Case of the first point to achieve the nominal second SPS burn conic

[4] Case of the maximum second SPS burn duration

[5] Nominal second S-IVB cutoff

Table 10. Alternate Mission Characteristics for the Case of No Second S-IVB Burn Without Second SPS Burn

Event	Time From Lift-off (hr:min:sec)	Altitude[1] (ft)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Inertial Azimuth (deg)
Contingency	03:10:09.4	670,361	32.47	-87.99	25,555	-0.017	94.37
CSM/S-IVB Separation	03:10:11.1	670,338	32.47	-87.86	25,555	-0.017	94.44
First SPS Ignition	03:11:49.4	667,731	31.70	-80.46	25,557	-0.063	98.59
First SPS Cutoff	03:19:14.4	1,778,283	21.81	-46.93	31,553	13.841	114.91[3]
Apogee	06:24:04.0	72,841,819	-32.10	47.86	7,416	0.000	83.23
Entry Interface	09:33:02.4	400,000	32.61	162.39	32,805	-5.947	87.12
Drogue Chute Deployment	09:46:03.0	23,500	28.26	-160.23	1,554	-14.418	93.15
Main Chute Deployment	09:46:51.0	10,200	28.26	-160.23	1,342	-9.728	90.00
CM Splash	09:51:49.0	0	28.26	-160.23	1,322	-1.200	90.00

[1]Altitude is measured above the Fischer Reference Ellipsoid.

[2]Minus sign indicates south latitude, west longitude, or an angle below the local horizonal.

[3]SPS guidance cutoff.

Table 11. Alternate Mission Characteristics for the Case of No Second S-IVB Burn with Second SPS Burn

Maximum Acceleration During Entry = 4.94 g's
Maximum Heat Rate During Entry = 196 BTU/sec
Total Heat Load During Entry = 27,627 BTU

Event	Time from Lift-off (hr:min:sec)	Altitude[1] (ft)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Inertial Azimuth (deg)
Contingency	03:10:09.4	670,361	32.47	-87.99	25,555	-0.017	94.37
CSM/S-IVB Separation	03:10:11.1	670,338	32.47	-87.86	25,555	-0.017	94.44
First SPS Ignition	03:11:49.4	667,731	31.70	-80.46	25,557	-0.063	98.59
First SPS Cutoff	03:19:14.4	1,778,283	21.81	-46.93	31,553	13.841	114.91[3]
Apogee	06:24:04.0	72,841,819	-32.10	47.86	7,416	0.000	83.23
Second SPS Ignition	09:24:26.8	4,211,504	22.94	121.13	29,586	-20.744	66.10
Second SPS Cutoff	09:24:41.9	4,051,735	23.33	122.03	30,100	-20.734	66.47[4]
Entry Interface	09:32:50.1	400,000	32.59	161.87	33,161	-5.920	86.81
Drogue Chute Deployment	09:45:47.0	23,500	27.35	-157.24	1,551	-14.396	93.11
Main Chute Deployment	09:46:35.0	10,200	27.35	-157.24	1,342	-9.728	90.00
CM Splash	09:51:33.0	0	27.35	-157.24	1,322	-1.200	90.00

[1] Altitude is measured above the Fischer Reference Ellipsoid.

[2] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[3] First SPS guidance cutoff

[4] Second SPS fuel depletion cutoff; nominal second SPS conic not achieved

Table 12. Alternate Mission Characteristics for the Case of the First Point to Achieve the Nominal Second SPS Burn Conic

Maximum Acceleration During Entry = 5.73 g's
Maximum Heat Rate During Entry = 370 BTU/sec
Total Heat Load During Entry = 38,800 BTU

Event	Time from Lift-off (hr:min:sec)	Altitude[1] (ft)	Geodetic Latitude[2] (deg)	Longitude[2] (deg)	Inertial Velocity (ft/sec)	Inertial Flight-path Angle[2] (deg)	Inertial Azimuth (deg)
Contingency	03:12:48.0	697,604	30.86	-75.30	29,325	1.310	101.38
CSM/S-IVB Separation	03:12:49.7	698,729	30.83	-75.16	29,323	1.342	101.46
First SPS Ignition	03:14:28.0	809,273	29.04	-67.05	29,211	3.132	105.70
First SPS Cutoff	03:19:05.9	2,048,393	21.38	-45.97	31,320	14.840	115.24[3]
Apogee	06:23:21.0	72,844,471	-32.26	46.04	7,416	0.000	84.28
Second SPS Ignition	09:23:44.8	4,207,857	22.24	119.65	29,589	-20.734	65.49
Second SPS Cutoff	09:26:46.1	2,263,118	27.12	132.23	35,012	-17.757	71.05[4]
Entry Interface	09:30:52.3	400,000	32.16	156.27	36,500	-6.496	83.56
Drogue Chute Deployment	09:44:47.0	23,500	27.30	-157.16	1,375	-16.514	97.31
Main Chute Deployment	09:45:35.0	10,200	27.30	-157.16	1,342	-9.728	90.00
CM Splash	09:50:33.0	0	27.30	-157.16	1,322	-1.200	90.00

[1] Altitude is measured above the Fischer Reference Ellipsoid.

[2] Minus sign indicates south latitude, west longitude, or an angle below the local horizontal.

[3] First SPS guidance cutoff

[4] Second SPS guidance cutoff

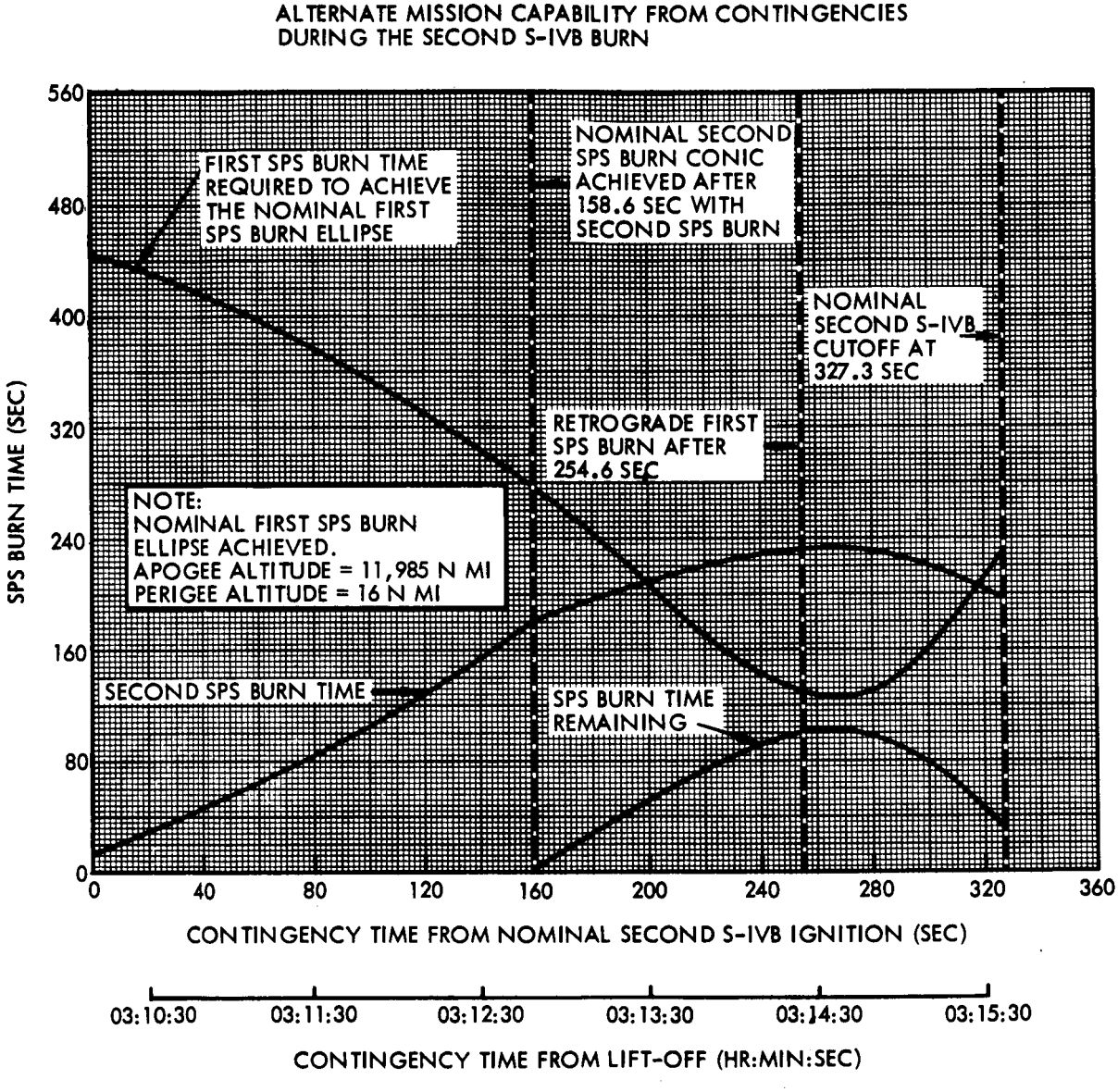


Figure 10. SPS Burn Time for Contingencies During the Second S-IVB Burn

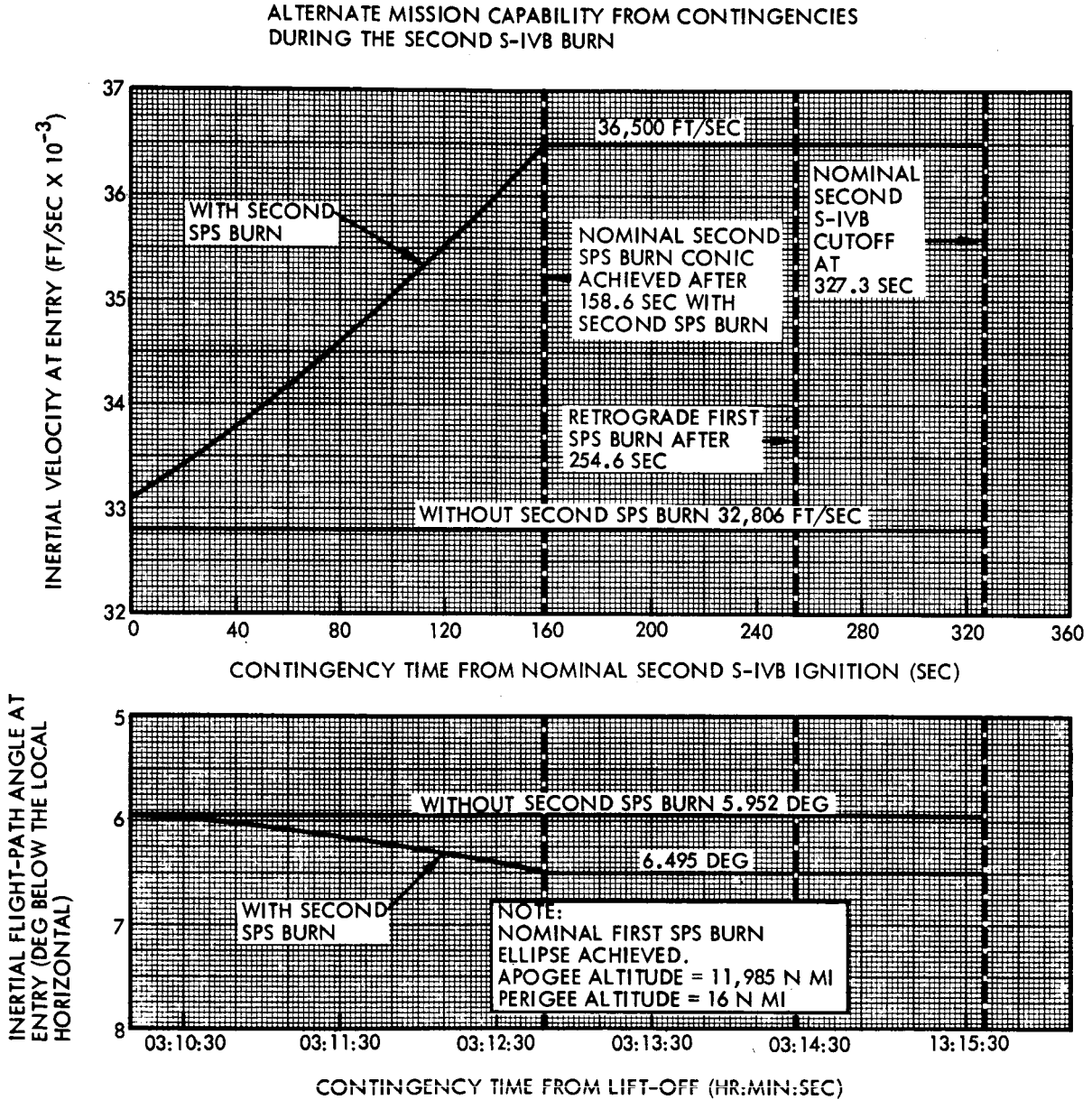


Figure 11. Inertial Velocity and Flight-path Angle at Entry for Contingencies During the Second S-IVB Burn

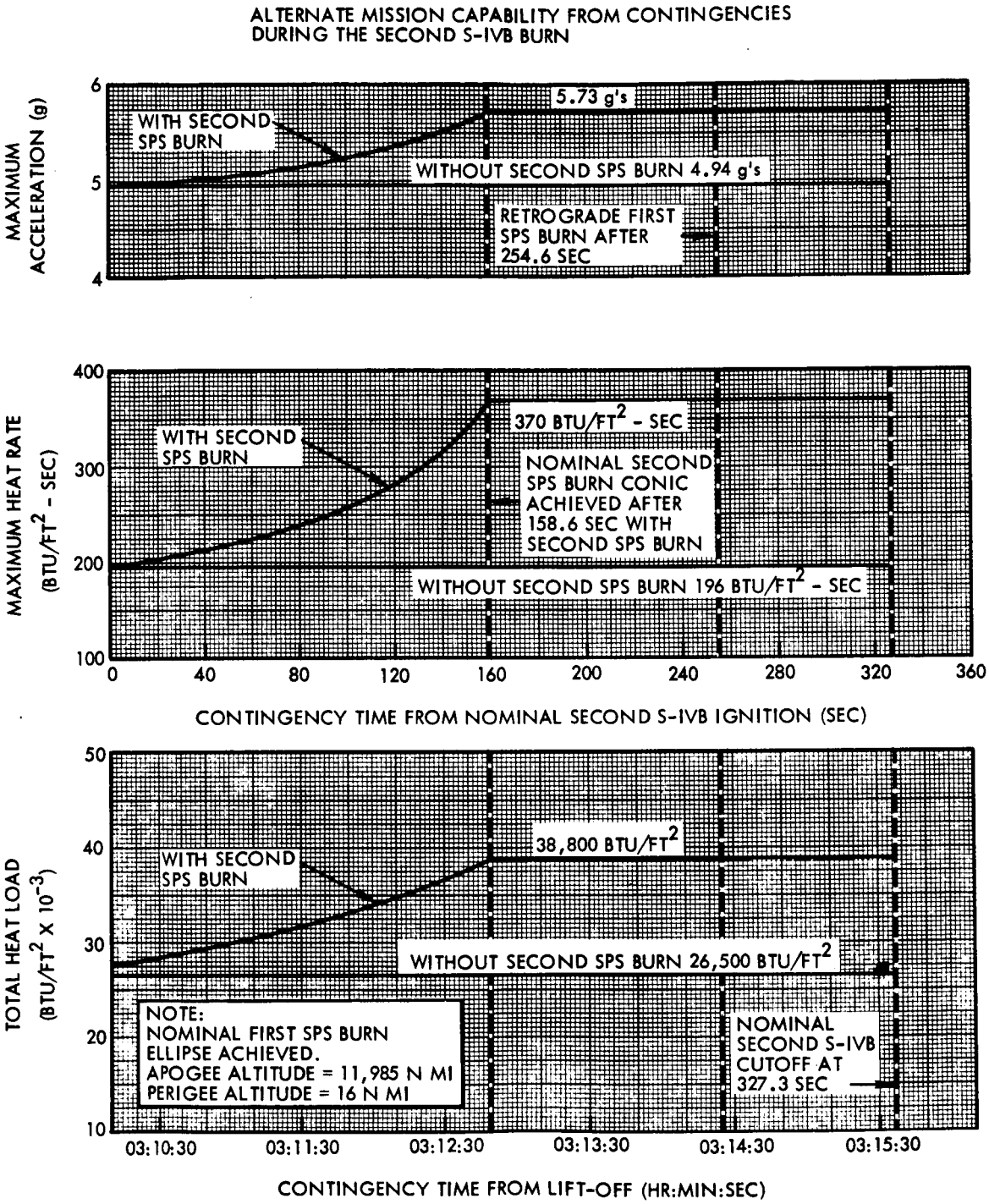


Figure 12. Maximum Acceleration, Heat Rate, and Total Heat Load During Entry for Contingencies During the Second S-IVB Burn

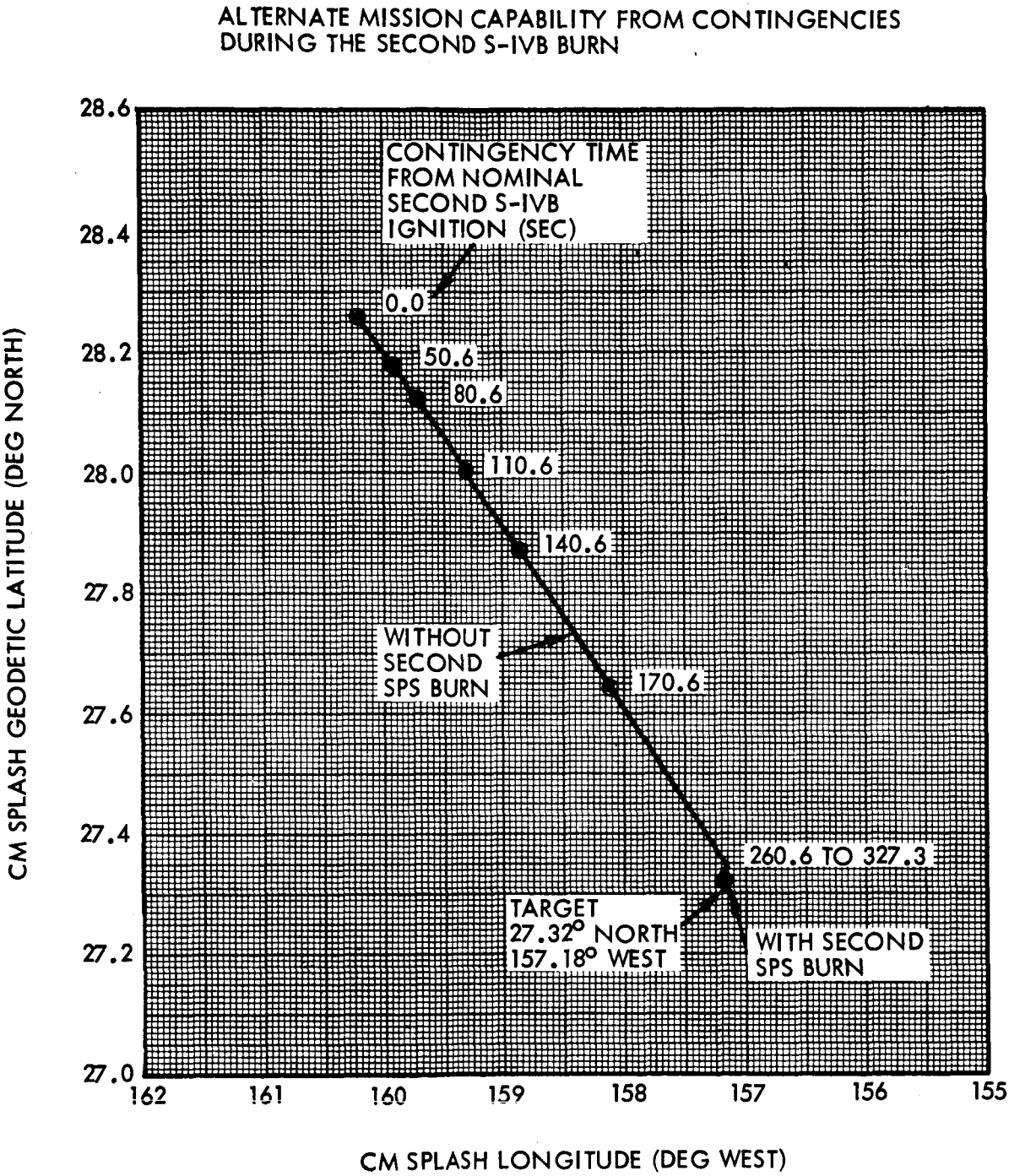
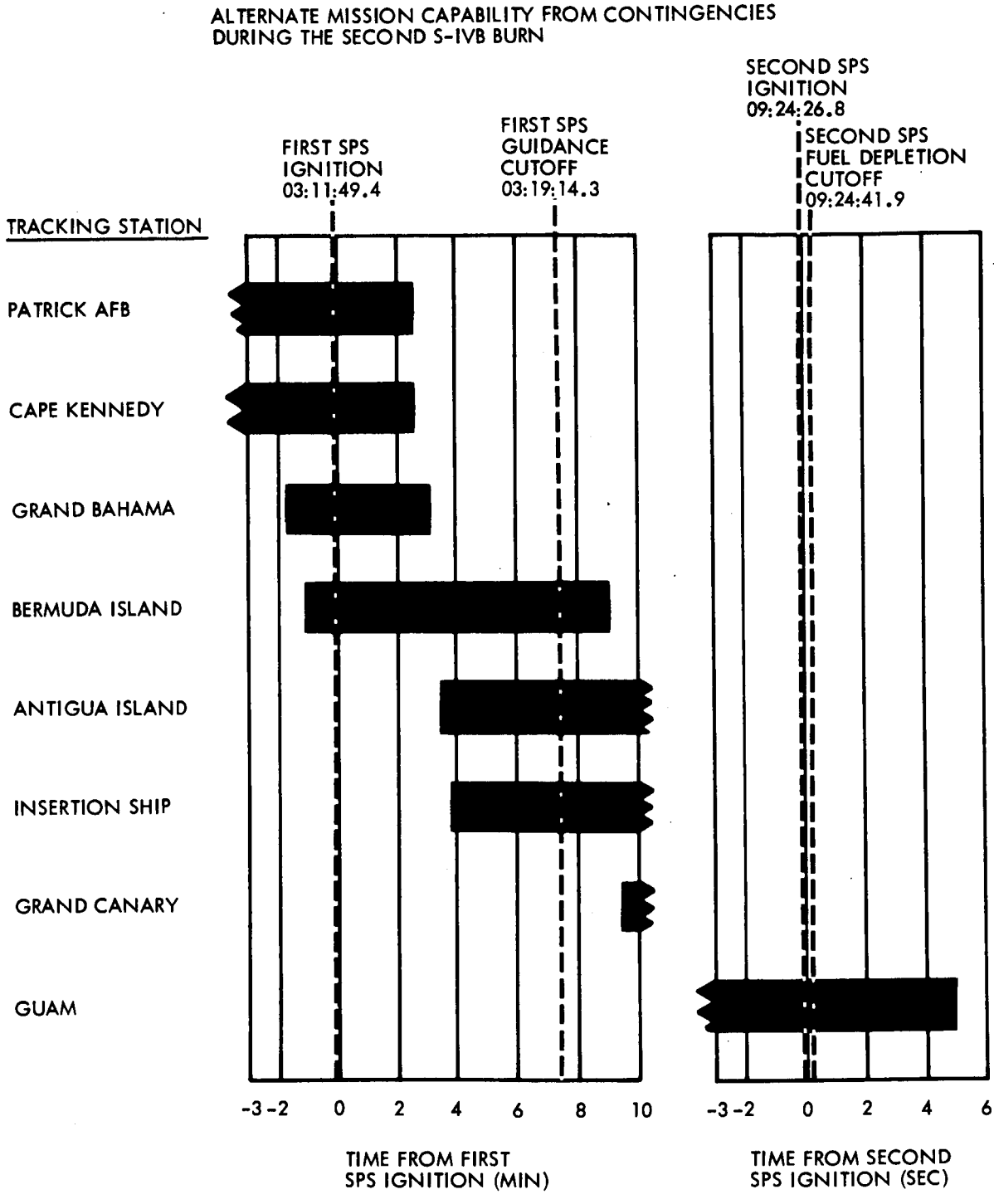


Figure 13. Map of CM Splash Points for Contingencies During the Second S-IVB Burn



CONTINGENCY TIME EQUALS 3 HOURS 10 MINUTES 9.4 SECONDS FROM LIFT-OFF
NOTE: ACQUISITION AND LOSS OF SIGNAL BASED ON A 5-DEGREE ELEVATION ANGLE

Figure 14. Tracking and Communications Coverage versus SPS Burn Time; Case of No Second S-IVB Burn

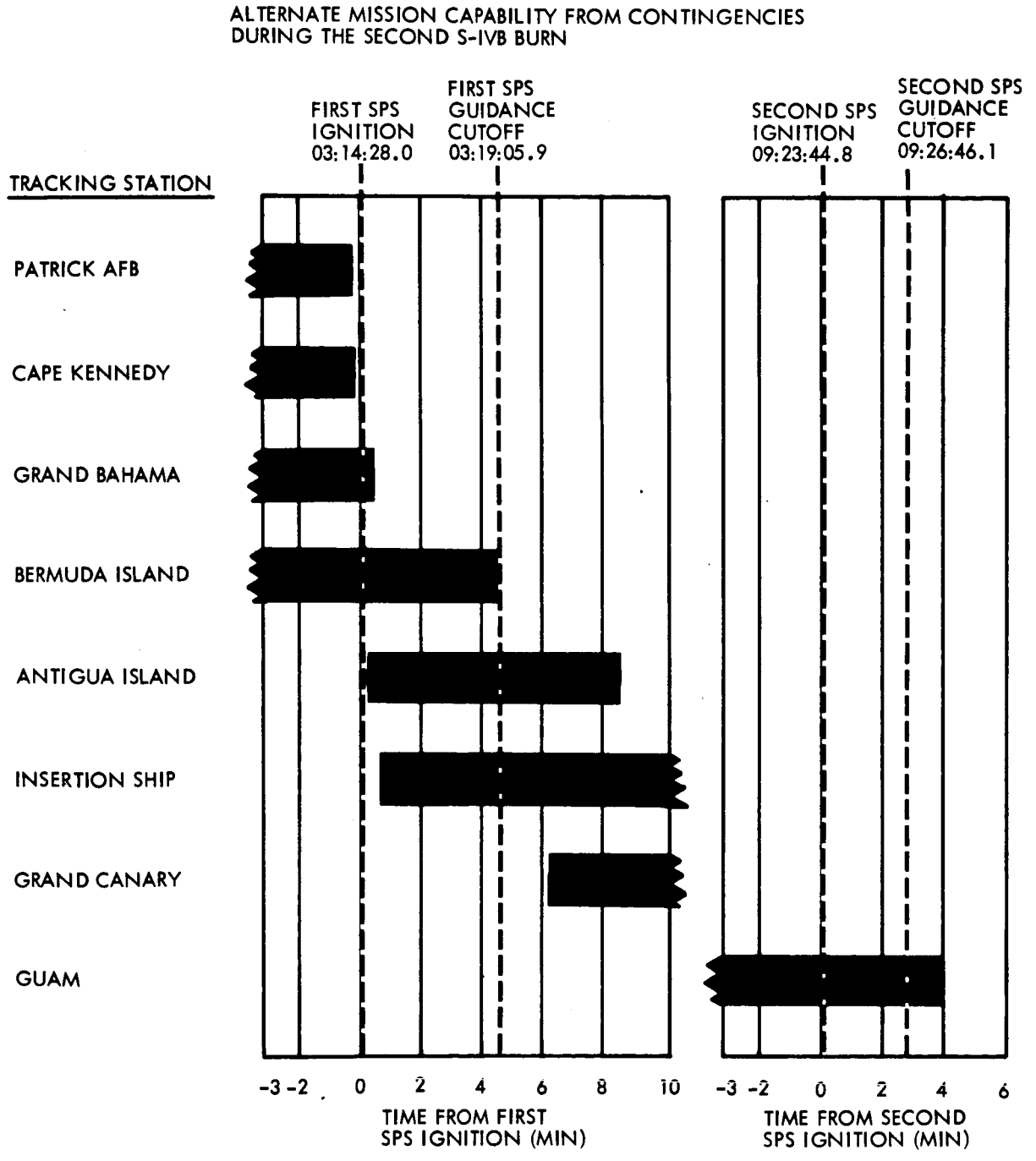


Figure 15. Tracking and Communications Coverage versus SPS Burn Time; Case of the First Point to Achieve the Nominal Second SPS Burn Conic

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